PHENIX DC Operation in the PEH

PHENIX Procedure No. PP-2.5.2.4-01

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Hand Processed Changes

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1. Purpose

The purpose of this document is to specify the operation of the Gas, High Voltage and Low Voltage Systems for the PHENIX Drift Chambers

This document describes:

1.1 On start-up:

1.1.1 the initiation of flammable gas flow in the Drift Chambers,

1.1.2 the first time high voltage is applied to the chambers after flammable gas is flowing,

1.2 For normal running:

1.2.1 the standard procedure for maintaining operating gas flow

1.2.2 the standard procedure for turning on and off high voltage

1.2.3 the standard procedure for turning on and off the low voltage

Because the PHENIX Drift Chambers and PHENIX Pad Chambers share a single gas system, much of this document is exactly the same as the corresponding Pad Chamber Procedure.

2. Responsibilities

During any data taking period there will be at least four people on shift in the PHENIX counting house. Prior to data taking, there will be a period of chamber commissioning when the chambers are flushed with operating gas and tested at high voltage. After the introduction of flammable gas to the Drift Chambers (or any other subsystem) there shall be at least two people on shift at all times.

High Voltage (HV) and Low Voltage (LV) power shall not be left operating unattended.

During commissioning, it will be the responsibility of the Gas Experts to establish the flow of operating gas, as described in Sec. 6.1. During this period there can be no high voltage on the Drift Chambers. It is the responsibility of the Drift Chamber Gas Experts to ensure that the HV is off during this period.

During commissioning, it is the responsibility of the Drift Chamber Experts to bring on the HV in a safe manner, as described in Sec. 6.4.

During commissioning, it is the responsibility of the Drift Chamber Experts to bring on the LV in a safe manner, as described in Sec. 6.6.

During data taking, it will be the responsibility of the PHENIX Shift Crew to:

2.1 Monitor the status and alarms of the gas system according to a prescribed check off list (Attachment 1) at least once a shift (eight hours).

2.2 Monitor the status and alarms of the HV system throughout the shift, according to a prescribed checklist (Attachment 2).

2.3 Monitor the status and alarms of the LV system throughout the shift, according to a prescribed checklist (Attachment 3).

2.4 In the event of an alarm or irregularity, contact an expert from the Expert Call List (Attachment 4).

It is the responsibility of the Gas Experts to:

2.5 maintain the Drift Chamber Gas System in a safe operating condition. This includes:

2.5.1 changing gas cylinders and dewars when required,

2.5.2 setting, adjusting, and checking the gas mixture, flow rates and pressures

2.5.3 posting any special instructions or notifications as required, and

2.5.4 carrying out any emergency actions, as prescribed in the Procedures section of this document.

2.6 maintain the Drift Chamber HV System in a safe operating condition. This includes

2.6.1 verifying the readiness of the chamber for HV,

2.6.2 turning on the HV according to the operating procedures described below,

2.6.3 posting any special instructions or notifications as required, and

2.6.4 carrying out any emergency actions, as prescribed in the Procedures section of this document.

2.7 maintain the Drift Chamber Low Voltage System in a safe operating condition. This includes:

2.7.1 Verifying the readiness of the chamber for low voltage power

2.7.2 Turning on the LV according to the operating procedures described below,

2.7.3 Posting any special instructions or notifications as required, and

2.7.4 carrying out any emergency actions, as prescribed in the Procedures section of this document.

3. Prerequisites

The Drift Chamber Gas Experts shall have read or have training in the following areas:

3.1 C-A Local Emergency Plan for the Collider-Accelerator Department, C-A_3.0,

3.2 BNL Compressed Gas Safety Training Course,

3.3 PHENIX Emergency Plan C-A_3.16

3.4 geographical layout of the experimental area (routes of egress, location of emergency equipment, phones and controls)

4. Precautions

The PHENIX Safety Monitoring and Control System (SMCS) is interlocked with the power to the Gas Room of the Mixing House (MH). In the event of any Level 3 alarm, all power to the Gas Room of the MH is shut off.

The Level 3 alarms include:

- Detection of flammable gas by the VESDA system in the Interaction Region (IR),

- Detection of smoke by the HSSD system in the IR.
- Flammable gas alarms in the MH.
- Heat sensor alarms in the MH.

4.1 Gas System Precautions:

4.1.1 The SMCS is interlocked with the power to the Gas Room of the Mixing House (MH). In the event of a Level 3 alarm, all power to the Gas Room of the MH is shut off. When this occurs, solenoid valves in the flammable gas lines shut automatically and other valves drop to a designated "safe state". In order to verify the safe status, flow indicators in the gas lines report the flow rate of flammable gas back to the PHENIX Counting Room (CR). This leaves the Drift Chambers in a designated Safe State, filled with operating gas, but being purged with inert gas.

4.1.2 All gas cylinder storage is on the PHENIX Gas Pad located just south and east of the PHENIX Gas Mixing House. All gas cylinders and dewars are to be changed by designated PHENIX personnel with current BNL Compressed Gas Safety Training.

4.1.3 All valves and controls associated with the DC Gas system are to be operated by designated DC gas system experts with current training.

4.1.4 Primary care should be given to monitoring the internal pressure of the DC throughout the duration of the start-up procedure, especially when adjusting flow rates. Over-pressurization of the DC (above 25.0 mm WC) can result in permanent deformation of the detector windows.

4.2 High Voltage System Precautions:

4.2.1 The SMCS is interlocked with the High Voltage (HV) power supplies. Activation of the alarms automatically shuts down the power to all HV supplies,

4.2.2 The total stored electrical energy in the high voltage systems is low. The HV power supplies are current limited to less than 10 microamps per channel. An insulating layer covers all HV points in order to eliminate the danger to personnel. When the Drift Chambers are mounted on the carriage the HV points are inaccessible to personnel

4.2.3 Before any HV can be turned on, sufficient gas must have flowed through each of the detectors to remove oxygen from the chambers. This will be accomplished by purging the chambers with inert gas prior to the introduction of flammable gas. The gas flow rate is 7.5 Standard Cubic Feet per Hour (SCFH) to each chamber. Each chamber has a gas volume of 75 cubic feet. Thus it will take 10 hours for a single exchange of gas, or 30 hours for 3 volume exchanges. So flammable gas shall not be introduced into the chambers until they have been purged with inert gas for at least 30 hours. This ensures that there will not be a flammable mixture in the chambers or gas system.

4.2.4 For the safety of the chambers, HV will not be turned on, except for low voltage testing, until operating gas has filled the chamber. Voltages less than 500 volts may be applied to the chambers for short periods of time provided the operation is monitored at all times by a Drift Chamber expert. In order to raise the HV to operating voltage, the chamber must be filled with operating gas. This means that operating gas must have been flowing for at least 30 hours prior to increasing the HV above 500 volts.

4.2.5 All HV controls associated with the DC HV system are to be operated by designated DC HV experts only, or by the PHENIX shift leader following specific instructions from DC experts (see Attachment 4)..

4.3 Low Voltage System Precautions:

4.3.1 The SMCS is interlocked with all power to the PHENIX hall including the Low Voltage (LV) power supplies. Thus, activation of the alarms automatically shuts down the power to all LV supplies. The LV system is used to provide power to the Drift Chamber Front End Modules (FEMs) that are monitored by 483 temperature probes. Overtemperature indication on selected probes will shut off power to the entire drift chamber.

4.3.2 Any reconfiguration of the DC LV beyond turning the power on/off is to be performed by DC LV experts only, or by the PHENIX shift leader following specific instructions from DC experts (see Attachment 4).

5 Emergency Procedures

In the event of an emergency, follow the procedures outlined in PHENIX Emergency Procedure 3.16 detailed below.

5.1 In the event of a fire or fire alarm in Building 1008, members of the PHENIX Shift Crew shall (in order of priority)

5.1.1 Pull the nearest fire alarm if the alarm is not already sounding (Attachment 1 gives the layout of the building 1008 showing the location of the gas system area and the fire alarm pull stations in the area),

5.1.2 Go to a safe location and call 911 or 2222.

5.1.3 Await the arrival of the Fire/Rescue Group. If the fire is small, the Shift Crewmember may return to the area and attempt to extinguish the fire using a fire extinguisher.

5.1.4 The Shift Leader shall report to the Fire/Rescue Captain upon arrival at the Command Post.

5.2 In the event of an emergency related specifically to the Drift Chamber gas or electronics,

5.2.1 The SMCS is interlocked with the Gas, HV and LV power supplies. Activation of the alarm automatically shuts down the flammable gas flow and all power to HV and LV supplies. No further action is needed for this.

5.2.2 Notify the Drift Chamber Expert On Call that an emergency affecting the Drift Chambers has occurred

6 Standard Operating Procedures

There are three elements to these Operating Procedures. The first element covers running flammable gas to the Drift Chambers. The second covers the high voltage system for the chambers. The third covers the low voltage system for the chambers. Only Drift Chamber Experts shall carry out these Procedures.

The Gas system for the DC is composed of a number of components.

1. Argon cylinders and cryogenic dewars located on the PHENIX Gas Pad, with regulators, evaporators, control and relief valves
2. Ethane cylinders located on the PHENIX Gas Pad, with regulators, control valves and relief valves
3. Argon and Ethane distribution manifolds located in the PHENIX Mixing House 1008F
4. DC/PC Gas rack located in the Gas room in 1008F

5. DC/PC Electronics Rack located in the Electronics room of 1008F
6. TEC/DC/PC carriage gas rack located underneath the East Carriage in the PHENIX IR.
7. DC/PC carriage gas rack located underneath the West Carriage in the PHENIX IR.
8. DC-1 supply manifold with control valves mounted in the base of the East and West Carriage.
9. DC-1 return manifold with flowmeters mounted in the base of the East and West Carriage.
10. DC-3 supply and return manifolds with control valves and -flowmeters mounted in the base of the East Carriage.
11. Normal venting to the PHENIX Mixing House Vent Stack
12. Emergency Venting to the PHENIX Low Capacity Vent Stack.

For details of the Drift Chamber Gas System schematics, please refer to Attachment 6. The labels of valves and meters in the operation instructions below refer to parts identified in the figures in Attachment 6.

6.1 *Gas System Procedures*

Before flowing flammable gas to the Pad Chambers, or any other PHENIX subsystem, call the Main Control Room (MCR) and notify them that flammable gas is being introduced to the IR. MCR shall also be notified before the flammable gas is purged from any PHENIX subsystem.

The Procedures describe starting gas flowing to the DC after a long shutdown. They assume no gas is currently flowing, no flowmeters are adjusted and the PHENIX IR is open. If the PHENIX IR is closed it is necessary that the DC/PC carriage rack and flow meters must have been previously adjusted prior to any gas flow. If no gas has been flowing in the DC for 24 hours one must start flowing inert gas first.

6.1.1 Power on the DC/PC Electronics Rack (Note: If system is powered on, go to step 6.1.2)

6.1.1.1 Turn on AC power for Electronic Rack (Receptacles Breaker)

6.1.1.2 Turn on mass flow controller power supplies (Electronic Rack)

6.1.1.3 Turn on Keithley Digital Multimeter and High Density Switch System

6.1.1.4 Turn on Alarm/Interlock box

6.1.1.5 Turn on and boot the gas system PC.

6.1.1.6 Start the gas system control program.

6.1.1.7 Turn on Power Supplies Breaker

6.1.1.8 Turn on AC power for Gas Rack

6.1.2 Verify that Argon is flowing to the chambers at ~3 LPM.

6.1.3 Verify that the manual valve MV-E10 on the Ethane Distribution Panel in the Mixing House is closed.

6.1.4 Open the six valves on top of the Ethane cylinder six-pack on the Gas Pad.

6.1.5 Open the valve MV-E1A allowing Ethane to flow from the cylinders to fill the manifold.

6.1.6 If more than one six-pack is being used, repeat steps 6.1.3 and 6.1.4 for all six-packs.

6.1.7 Open valves MV-E2A, MV-E3A and MV-E4 to allow Ethane to flow to the regulator on the Ethane manifold.

6.1.8 Adjust the manifold to 40 psig.

6.1.9 Open the valve MV-E8 to allow Ethane to flow into the pipes running to the Mixing House.

6.1.10 Verify that the manual valve outside the mixing house, MV-E9 is open.

6.1.11 Open MV-E10 on the Ethane Distribution Panel inside the MH.

6.1.12 Verify that the solenoid valve AV-E1 is powered and open.

6.1.13 Adjust the regulator PI-E3 to 20 psig.

6.1.14 Slowly open the relief valve MV-E13 and allow the Ethane Gas to flow though the piping to the MH, purging the line of oxygen. After the line is purged, (about 1 minute), close the relief valve again.

6.1.15 Open the valve MV-E11A to allow flow to the flow meter in the Ethane Distribution Panel.

6.1.16 Open the flow meter valve FM-E1A allowing flow to the DC/PC Gas Rack.

6.1.17 Verify that the solenoid valves SV16, SV18, SV20 and SV22 are open. These valves are in the IR, with control and monitoring on the DC/PC Gas Computer in the MH Computer Room. This allows gas to flow to the DC and/or PC.

6.1.18 Open the solenoid valve SV8 on the DC/PC Gas Rack by clicking on the SV8 icon on the DC/PC Gas Computer in the MH Computer Room.

6.1.19 Verify that the Mass Flow Controller FM1 is set to 10 SCFH.

6.1.20 Set the Mass Flow Controller FM2 to 10 SCFH on the computer. The Argon Gas Mass Flow Controller FM1 should be set already to 10 SCFH.

6.1.21 Open MV-8 to allow flow through the Bypass Flow Meter FI2 on the DC/PC Gas Rack. This allows gas to escape from the DC/PC piping to the vent outside the MH. Allow the Ethane Gas to flow for several minutes to purge the piping of any oxygen in the pipes.

6.1.22 Close MV-8.

6.1.23 The Flow Meter FI12 should be set already to 5 SCFH, and the valve MV9 should be closed. FI12 can be viewed on the video monitor in the CR.

6.1.24 Verify that the exhaust valve SV17 is open allowing Argon/Ethane Gas to flow back to the vent in the MH.

6.1.25 The Flow Meter FI15 should be set already to 2 SCFH, and the valve MV15 should be closed. FI15 can be viewed on the video monitor in the CR.

6.1.26 Verify that the exhaust valve SV23 is open allowing Argon/Ethane Gas to flow back to the vent in the MH.

6.1.27 Adjust the Mass Flow Controllers FM1 and FM2 to give a 50/50 mixture of Argon and Ethane Gas and sufficient flow through the Drift Chambers. At this point the Ethane Mass Flow

Controller is slaved to the Argon Controller so that a 50/50 mixture is maintained. If the Ethane fraction should rise from 50 to 51%, a warning alarm is given to the gas monitor. A PHENIX shift person shall notify a DC Gas Expert of the discrepancy. If the Ethane fraction should rise as high as 52%, a serious alarm is raised and the Ethane flow is shut off. PHENIX Shift personnel shall notify a DC Gas Expert of this alarm condition.

6.1.28 Verify that the gas flow to each chamber is at 7.5 SCFH by checking the individual flowmeters locate on the gas manifolds under the East and West Carriages.

6.1.29 Record the time and date that gas flow was started for each chamber.

6.1.30 Allow the chamber to flow Mixed Gas until there has been at least three exchanges of gas inside the chamber. This represents about 30 hours for the Drift Chambers.

6.1.31 It is now safe to turn on the high voltage on the chamber.

6.2 Gas System Procedures: In order to change a six-pack of gas cylinders:

6.2.1 Close the valve on the six-pack in use: either MV-E1A, MV-E1C, MV-E1E, MV-E1G, MV-E1J or MV-E1L.

6.2.2 Open the valve to the full six-pack.

6.2.3 Verify that the regulator is set to 40 psig.

6.2.4 Record the starting cylinder pressure and the time and date in the gas logbook.

6.3 Gas System Procedures: In order to shut off all flammable gas flow:

6.3.1 Close the Manual Valve MV-E10 on the Ethane Gas Distribution Panel.

6.3.2 Record the pressure remaining in the cylinders, and the time and date in the gas logbook.

6.4 HV System Procedures: Turning on HV:

If the HV is being turned on for the first time, verify by checking with a Drift Chamber Gas Expert that operating gas has been flowing to the Drift Chambers for at least 30 hours before attempting to bring on the HV.

6.4.1 Check that the appropriate current limits are in place for the power supply. These limits are given in Attachment 2. The Drift Chamber Experts shall maintain a HV logbook where the operating parameters of the HV settings are recorded. This shall include the current limits, target voltages, ramp rates, operating voltages and currents, and trip tolerances.

6.4.2 As a check, the chamber is to be turned on at very low voltage to identify any broken wires. Set the target voltage for each HV output channel to 10 volts.

6.4.3 Check that the ramp up rate for each HV channel is appropriate (10 volts per second).

6.4.4 Ramp up the HV.

6.4.5 If any of the HV channels trips, disable that and the neighboring HV channels until the reason for the trip is understood. Then begin the procedure again from 6.4.1

6.4.6 If there are no HV trips, verify that the operating currents are appropriate.

6.4.7 Change the target voltage to the correct operating voltage for each chamber, as given in Attachment 2.

6.4.8 Continue ramping up the HV.

6.4.9 When ramping is complete, verify that the operating currents are appropriate, as given in Attachment 2.

6.4.10 HV is ready for chamber testing.

6.5 HV System Procedures: Turning off High Voltage to a chamber:

6.5.1 Begin ramping down the HV.

6.5.2 Verify by the read back that the HV is off the system.

6.5.3 In the event of irregularities, call a Drift Chamber Expert.

6.6 LV System Procedures: Turning on Low Voltage:

6.6.1 Verify that the AC is on to the LV crate.

6.6.2 Click on the appropriate button to turn LV power on to the channel required.

6.6.3 Verify that the button changes color to indicate power is on (RED). This may take ten to twenty seconds. If not, call a Drift Chamber Expert.

6.6.4 Verify that the temperature monitors are within tolerance by checking Attachment 3. If not, call a Drift Chamber Expert.

6.7 LV System Procedures: Turning off Low Voltage:

6.7.1 Click on the appropriate button to turn LV power off to the channel required.

6.7.2 Verify that the button changes color to indicate power is off (GREEN). This may take ten to twenty seconds. If not, call a Drift Chamber Expert.

7 Documentation

The Drift Chambers shall maintain a separate logbook for the Gas System Status, HV Status, and LV Status

8 References

8.1 C-A_3.0, "Local Emergency Plan for the Collider-Accelerator Department."

8.2 BNL SBMS , ESH Section 1.4.0, "Compressed Gas Cylinder Safety, Rev. 1", March, 1999.

8.3 BNL Occupational Health and Safety Guide (Interim), Section 4.11.0, "Installation of Flammable Gas Systems (Experimental & Temporary Installations)", June 21, 1989.

8.4 Nitrogen Purge and Shutdown of the PHHENIX DC/PC Gas System after Ar+50% Ethane

Mixture Operation, Rev. 1, May 3 2000, Leonid Kotchenda

8.5 Procedure for Starting the Drift and Pad Chambers Gas System and Purging the DC/PC with Dry Nitrogen (non recirculation version), Rev. 1, May 3 2000, Leonid Kotchenda.

8.6 Operating the PHENIX Drift and Pad Chambers Gas System with Ar + 50% Ethane Mixture (non recirculation version), Rev. 1, May 3 2000, Leonid Kotchenda.

9 Appendix A

9.1 Attachment 1: - Check list for the Drift Chambers Gas System

9.2 Attachment 2: - Check list for the Drift Chamber High Voltage System

9.3 Attachment 3: - Check list for the Drift Chamber Low Voltage System

9.4 Attachment 4: - Call list for the Drift Chamber Gas, HV, and LV Experts.

9.5 Attachment 5: - Alarm Conditions

- 9.5.1 Computer Alarms
- 9.5.2 Hardware Alarms

9.6 Attachment 6 – Schematic of the Drift Chamber Gas System.

- 9.6.1 PHENIX Drawing Number 105-0508-050-4: PHENIX Cryogenic and Compressed Gas Storage and Supply P & ID.
- 9.6.2 PHENIX Drawing Number 002-0205-671: PHENIX Drift Chamber DC/PC Gas System.

Attachment 1. PHENIX DC/PC GAS SYSTEM CHECK LIST

(To be filled out every 12 hours and placed in Gas System Binder.)

Computer Monitored Sensors

Sensor	Function	Value	Range	Comments
PT1	Bleed-off Pressure		0.0mbar	N/A Run-00
PT2	Input of Big Compressor		1.0 - 2.0mmWC	N/A Run-00
PT5	Input of East PC		1.0 - 1.5"WC	
PT6	Input of East DC		2.5-5.0mmWC	
PT7	Input of West DC		2.5-5.0mmWC	
PT8	Input of West PC		1.0 – 1.5”WC	
PT9	Return Bypass pressure		2.0-4.0”WC	
PI2	Output of Big Compressor		35-45”WC	N/A Run-00
PI3	Supply pressure		2.0-6.0”WC	
PI6	Argon Delivery pressure		15-21PSIG	
PI7	Ethane Delivery pressure		12-16PSIG	
PTB	Barometric pressure		800-1100mBar	
FI1	Flow indicator		9-20LPM	
FM1	Argon mass flow controller		4.9-5.1LPM	
FM2	Methane mass flow controller		4.9-1.1 LPM	
PID	PID Controller		0.0	N/A Run-00
H20	Water analyzer		0.0ppm	N/A Run-00
C2H6	Ethane analyzer		0.0%	N/A Run-00
O2	Oxygen analyzer		0.0ppm	N/A Run-00
FDI1	Flow direction indicator East PC			
FDI2	Flow direction indicator East DC			
FDI3	Flow direction indicator West DC			
FDI4	Flow direction indicator West PC			
TT1	East DC Output Temperature		295- 310K	
TT2	West DC Output Temperature		295- 310K	

TT3	East PC Output Temperature		295- 310K	
TT4	West PC Output Temperature		295- 310K	
TT5	Input Chambers Temperature		295- 310K	
C2H6/FM	Ethane content		49.5-50.5%	
LEAK	Leakage		0.0LPM	

Gas Rack

PI1	Input of Big Compressor		1.0-2.0mmWC	N/A Run-00
PI2	Output of Big Compressor		35-45”WC	N/A Run-00
PI3	Supply pressure		2.0-4.0”WC	
PI6	Argon Delivery pressure		15-21PSIG	
PI7	Ethane Delivery pressure		12-16PSIG	
FI16	Purging flow for PI1 case		1.0LPM	N/A Run-00

Gas Pad

Ethane Bank			0 - 2000 PSIG	
Argon Bank			0 - 2000 PSIG	

Electronic Rack

Sensor	Function	Value	Range	Comments
FM1	Argon mass flow controller		4.9-10 LPM	
FM2	Ethane mass flow controller		4.9-10 LPM	
FI1	Flow indicator		9-20 LPM	

Mixing Room Manifold

Sensor	Function	Value	Range	Comments
PR-N3	Nitrogen Supply Pressure		15 PSIG	N/A Run-00
PR-A3	Argon Delivery Pressure		20 PSIG	
PR-E3	Ethane Delivery Pressure		15 PSIG	

Attachment 2: DC HV Settings

Each DC chamber has 4 separate types of HV: Cathode, Potential, Gate, and Back.

The nominal voltages for each of these is:

Cathode Voltage	**+4000 V**
Potential Voltage	**+2300 V**
Gate Voltage	**+1600 V**
Back Voltage	**+800 V**

NB: These voltages are subject to change as we learn about the chamber operation. Please refer to the DC HV Logbook for additional information on the HV settings.

Attachment 3: DC LV Settings

Each DC chamber has 14 separate channels of Low Voltage (LV).

The nominal voltages each Drift Chamber are all 48 VDC:

All thermocouple readings should be nominal (See Drift Chamber Low Voltage LogBook).

Attachment 4.1: DC Gas System Experts

The following people have been trained to operate the PHENIX DC gas system. They have completed the prerequisite BNL training courses (see 3.1).

Leonid Kotchenda	x5795
Peter Kravtsov	x5795
Thomas Hemmick	632-8111(office)
Vladislav Pantuev	632-8112

Additional qualified users are to be listed below and posted in the gas mixing house:

Attachment 4.2: DC High Voltage System Experts

The following people have been trained to operate the PHENIX DC HV system. They have completed the prerequisite BNL training courses (see 3.1).

Lesha Khanzadeev	x7821
Vladislav Pantuev	632-8112(office)

Additional qualified users are to be listed below and posted in the counting house:

Attachment 4.3: DC Low Voltage System Experts

The following people have been trained to operate the PHENIX DC LV system. They have completed the prerequisite BNL training courses (see 3.1).

Thomas Hemmick	632-8111(office)
Sergey Butsyk	632-9007(office)

Additional qualified users are to be listed below and posted in the counting house:

Attachment 5.1: Computer Alarm Conditions

Alarm Event	Problem	Level	Computer Action	Possible Causes
Ethane/FM Low Alarm	Fresh gas ethane content low	< 49.0%	Sound, Light	Ethane bottle empty; FM2 set wrong
Ethane/FM High Alarm	Fresh gas ethane content high	> 52.0 %	Off HV,SV6,SV8	FM2 set wrong.
PT9 High Alarm	East PC pressure too high	> 2.5 mmWC	Sound, Light	Makeup flow too high; No outlet flow
PT9 Low alarm	East PC Pressure too low	< 1.0 mmWC	Sound, Light	Makeup flow stopped; Argon empty, Leak
PT2 Low alarm	Return line pressure too low	< 0.3mmWC	Off HV,SV6, Sound, Light	Big leak, Makeup flow stopped
PT2 Low Warning Alarm	Return line pressure low	<0.5mmWC	Sound, Light	Leak; Makeup gas flow low;
PT2 High Warning Alarm	Return line pressure high	>1.8mmWC	Sound, Light	Makeup gas flow high, Restricted outlet flow
PT2 High Alarm	Return line pressure too high	> 2.5mmWC	Off HV,SV8 On SV7 Sound, Light	Makeup gas flow too high, PCV1 fails
PT11 Low Alarm	Return Bypass pressure low	< 2”WC	Sound, Light	Leak, Makeup flow low.
PT5 High alarm	East PC input pressure high	> 1.8”WC	Sound, Light	Input restriction to flow
PI2 Low Alarm	Makeup pressure low	< 20”WC	Sound, Light	PCV1 fails, Argon Bank empty
PI6 Low Alarm	Argon supply pressure low	<10PSIG	Sound, Light	Argon Bank empty, leak
PI7 Low Alarm	Ethane supply pressure low	<7PSIG	Sound, Light	Ethane Bank empty, leak

Note: High Warning = alert by the computer before alarm condition.

High Warning Return = alarm flag resets when sensor value returns to this number.

Attachment 5.2: Hardware Alarm Conditions

Alarm Event	Problem	Level	Action	Possible Causes
PT9 High Alarm	East PC pressure too high	> 2.5 mmWC	Sound, Light	Makeup flow too high; No outlet flow
PT9 Low alarm	East PC Pressure too low	< 1.0 mmWC	Sound, Light	Makeup flow stopped; Argon bank empty, Leak
PT2 Low alarm	Return line pressure too low	< 0.3mmWC	Off HV,SV6, Sound, Light	Big leak, Makeup flow stopped
PT2 Low Warning Alarm	Return line pressure low	<0.5mmWC	Sound, Light	Leak; Makeup gas flow low;
PT2 High Warning Alarm	Return line pressure high	>1.8mmWC	Sound, Light	Makeup gas flow high, Restricted outlet flow
PT2 High Alarm	Return line pressure too high	>2.5mmWC	Off HV,SV8 On SV7 Sound, Light	Makeup gas flow too high, PCV1 fails
PI2 Low Alarm	Makeup pressure low	< 20”WC	Sound, Light	PCV1 fails, Argon Bank empty

Alarm = Bell and red flashing light in mixing house. There is also an alarm condition notification through slow controls (EPICS) to run control.